Synopsis Submitted to

Swami Ramanand Teerth Marathwada University, Nanded, Maharashtra, India

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Title:

"Biomonitoring of Pesticide Pollution in Soil Using Earthworms As Biomarkers"

Synopsis Submitted

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SYNOPSIS

Abstract of proposed work plan / problem:

Pesticide pollution poses significant risks to soil health and biodiversity, impacting agricultural productivity and environmental sustainability. This study investigates the use of earthworms (*Eisenia fetida*) as bioindicators for monitoring pesticide contamination in soil. Earthworms are sensitive to changes in soil conditions, making them ideal for assessing the presence and impact of pesticides. The research involves a series of controlled laboratory and field experiments to evaluate the physiological and behavioural responses of earthworms to various pesticide concentrations. Initial findings suggest a strong correlation between pesticide concentration and adverse effects on earthworm health, indicating their effectiveness as bioindicators. This study also explores the potential of earthworms in bioremediation, where they aid in the degradation of pesticide residues, thereby improving soil health. The results underscore the importance of using biological monitoring tools in environmental management and sustainable agricultural practices. By leveraging earthworms as natural bioindicators, this research aims to develop cost-effective and efficient methods for monitoring and mitigating pesticide pollution in soils, ultimately contributing to a healthier environment and more sustainable agricultural systems.

1. Introduction:

The extensive use of pesticides in agriculture has raised significant environmental and public health concerns due to their persistence in the environment and potential to contaminate soil, water, and food supplies. Pesticide pollution not only disrupts soil ecosystems but also poses risks to human health and biodiversity. Therefore, effective monitoring and management of pesticide contamination in soil are imperative for sustainable agricultural practices and environmental protection.

Earthworms, particularly *Eisenia fetida*, have emerged as valuable bioindicators for assessing soil health and contamination. These organisms are highly sensitive to changes in their environment, including the presence of toxic substances. Their response to pollutants can provide crucial insights into the extent and impact of soil contamination. Many scientific reports indicate that, in addition to metals, pesticides are the most detected compounds in the environment. This situation is mainly due to the irrational use of the chemicals by humans. Mostly, soil environment changes caused by the influence of pesticides can be determined by various chemical analyses (Elzbieta *et al.,* 2022). They have been widely used to investigate the environmental impact of heavy metal contamination. Our understanding of pesticides' damaging effects on these animals is quite limited. Lumbricus terrestris was used as a bioindicator to investigate the effect of human activities on soil quality (Keshamma, 2022).

Annelids are the alternative approach of measuring soil response to contaminant exposure and then using them as biomarker for identifying level of pollutants and their adverse effect is gaining popularity. Invertebrates present in soil remain directly in contact with pore-water and soil and can serve as pollution bioindicators (Dahiya *et al.,* 2022). This study aims to explore the potential of earthworms as bioindicators for pesticide pollution in soil. By evaluating their physiological and behavioural responses to varying levels of pesticide exposure, we can develop a reliable biomonitoring system. Additionally, this research investigates the role of earthworms in bioremediation, examining their ability to degrade and mitigate pesticide residues in contaminated soils.

The significance of this study lies in its potential to offer a cost-effective, efficient, and ecologically sound approach to monitoring and managing pesticide pollution. By leveraging the natural bioindicating capabilities of earthworms, we can enhance soil conservation efforts, promote sustainable agriculture, and safeguard environmental and public health. The findings of this study will contribute to the development of policies and practices aimed at reducing the adverse effects of pesticide use, ensuring healthier ecosystems and communities.

2. Review of Literature and Development in the subject (Previous work done in the relevant area):

The use of earthworms as bioindicators for monitoring pesticide pollution in soil has gained significant attention in recent years. Several studies have highlighted the sensitivity of earthworms to various pesticides and their potential to provide valuable insights into soil health and contamination levels.

Mohd Yatoo *et al.*, (2022). Research work has shown that, highly sensitive to pesticides, and focused on the uses of pesticides, over two million tonnes of pesticides are currently used globally to improve crop production, yet these pesticides induce adverse effects on soil quality and biodiversity. Moreover, less than 1% of pesticides reach the target pests, while the rest contaminate the surrounding environment. Earthworms are exposed to pesticides and are thus an ideal biological model for ecotoxicological research. Pesticides can alter earthworm growth, reproduction, behavior, and enzyme activities even at low concentrations.

Keshamma E (2022). According to Keshamma Earthworms are considered as reliable bioindicators due to their role in soil ecosystems. Their presence and health can indicate the overall condition of the soil, including the presence of contaminants. They have been widely used to investigate the environmental impact of heavy metal contamination. Our understanding of pesticides' damaging effects on these animals is quite limited. Lumbricus terrestris was used as a bioindicator to investigate the effect of human activities on soil quality.

Celine Pelosi *et al.*, (2014). Studies have demonstrated that pesticides can disrupt soil ecosystems by affecting earthworm populations and their activities. This disruption can lead to reduced soil fertility and biodiversity. Earthworms' species based on their presence show the

effects of insecticides and fungicides and other most toxic pesticides impacting survival and reproduction, respectively.

Dhiman & Pant (2022). Work show that pollutants must be checked and monitored to revamp the health of the soil and henceforth utilization of earthworms gives an alternative yet stunning, novel, and biological monitoring tool to evaluate the hazardous impacts of the pollutants through biomarkers response and bioindication abilities. Earthworms end up being profoundly viable in monitoring the soil pollutants.

3. Objectives of Research / Proposed Hypothesis:

The present research work will be based on the following objectives. Some potential objectives for a research work will be based on the biomonitoring of pesticide pollution in soil using earthworms:

1. **To Evaluate the Sensitivity of Earthworms to Pesticides**: Determine how different pesticides affect earthworm survival, growth, reproduction, and behavior.
2. **To Assess Soil Health**: Use earthworms as bioindicators to monitor and assess the health of soils contaminated with pesticides.
3. **To Compare Biomonitoring Methods**: Compare the effectiveness of earthworm biomonitoring with traditional chemical analysis methods for detecting pesticide pollution.
4. **To Identify Biomarkers**: Identify specific biomarkers in earthworms that indicate pesticide exposure and soil contamination levels.
5. **To Develop Remediation Strategies**: Investigate the potential of earthworms in bioremediation processes to degrade or neutralize pesticides in contaminated soils.
6. **To Understand Ecological Impact**: Study the broader ecological impact of pesticide pollution on soil ecosystems, including interactions with other soil organisms and plants.
7. **To Promote Sustainable Agriculture**: Provide insights and recommendations for sustainable agricultural practices that minimize pesticide pollution and its impact on soil health.

These are some objectives which will be helpful for framing the research work.

Proposed hypothesis

"Earthworms (*Eisenia fetida*) can be effectively used as bioindicators to monitor the levels of pesticide pollution in soil, with measurable changes in their physiological and behavioural responses correlating to the concentrations of various pesticides. Furthermore, the presence and health of earthworm populations will provide a reliable indication of soil health and the effectiveness of bioremediation efforts."

This hypothesis suggests that earthworms will show specific responses to pesticide contamination, which can be quantitatively and qualitatively measured to assess the extent of soil pollution. It also posits that earthworms can play a role in bioremediation, aiding in the degradation of pesticides in contaminated soils.

4. Methodology to be adopted:

Methodology for Biomonitoring Pesticide Pollution in Soil Using Earthworms

a. Site Selection and Sampling

- Site Selection: Choose multiple study sites with varying levels of pesticide exposure, such as agricultural fields, non-treated areas, and control sites.
- Soil Sampling: Collect soil samples from each site at different depths (e.g., 0-10 cm, 10-20 cm) to assess pesticide distribution and soil properties.

b. Earthworm Selection and Preparation

- Earthworm Species: Select suitable earthworm species, such as *Eisenia fetida* known for their sensitivity to pesticides.
- Earthworm Cultivation: Maintain earthworm cultures in the laboratory under controlled conditions to ensure their health and suitability for experiments.

c. Laboratory Experiments

- Controlled Exposure: Expose earthworms to different concentrations of pesticides in controlled laboratory settings to determine their sensitivity and physiological responses.
- Monitoring Parameters: Measure parameters such as survival rate, growth, reproduction, enzyme activity (e.g., acetylcholinesterase, glutathione S-transferase), and behavioural changes.

d. Field Experiments

- Field Deployment: Deploy earthworm populations in the selected field sites and monitor their health, population dynamics, and soil conditions regularly (e.g., monthly).
- Soil and Earthworm Sampling: Collect soil and earthworm samples from the field sites for laboratory analysis to assess pesticide residues and soil health indicators.

e. Laboratory Analysis

- Chemical Analysis: Analyze soil samples for pesticide residues using techniques such as gas chromatography-mass spectrometry (GC-MS) or high-performance liquid chromatography (HPLC).
- Biomarker Analysis: Analyze earthworm samples for biomarkers of pesticide exposure, such as enzyme activity and oxidative stress markers.

f. Data Analysis and Interpretation

- Statistical Analysis: Perform statistical analysis on the collected data to identify significant trends and correlations between pesticide concentrations and earthworm responses.

g. Reporting writing & Publications

- Research Reports: Prepare detailed research reports, including methodology, results, and conclusions.
- Publication: Submit findings to peer-reviewed journals for publication to contribute to the scientific community's knowledge.

This methodology provides a comprehensive approach to biomonitoring pesticide pollution using earthworms, ensuring thorough data collection

Study Area:

Parbhani, earlier also known as “Prabhavatinagar”, is one of the Eight districts in the Marathwada region of Maharashtra State. This entire Marathwada region, a district geographical region, was a part of the erstwhile Nizam State, later a part of Hyderabad State, after reorganization of states in 1956 it became a part of the then Bombay state and from 1960 onwards it is part of the present Maharashtra state.

Geography

Parbhani district lies between 18.45 and 20.10 North Latitudes and 76.13 and 77.39 East Longitude. The district is bounded on the north by Hingoli and Buldhana districts. On the east by Nanded and Hingoli, on the South by Latur and on the West by Beed and Jalna districts. The hills on the northeast form part of the Ajanta Hill ranges which passes through Jintur Tahsil. The hills on the southern side are the Balaghat Hill ranges. The district is at an average height of 357 m from mean sea level.

Rivers:

Parbhani district is largely supported with a network of rivers which are tributaries of Godavari, the main river in the region; Godavari, Purna and Dudhana and its tributaries.

Source of Income

Agricultural Sector: One of the most important sectors of the Parbhani economy remains Agriculture. The agriculture sector in Parbhani is vast and vital, providing sustenance, employment, and economic strength to nearly half of the population.

The major crops of the Parbhani district are Jawar, Bajra, Wheat, Cotton, Gram, Tur, Udid, Groundnut, Maize, Safflower Sunflower and Oil Seeds and Onion. The fruits, condiment, food grain crop, and vegetables are also produced in study region.

5. Importance of study / Society application:

This study on biomonitoring pesticide pollution in soil using earthworms is vital for environmental protection, agricultural improvement, public health, and economic stability. Its societal applications extend to policy development, educational outreach, community involvement, and promoting sustainable practices. This research has the potential to create a healthier and more sustainable future for all. Improves agriculture by enhancing crop yields and reduces chemical use. The society reduces the risk of pesticide exposure and by reducing pesticide pollution in soil also helps in preventing the contamination of groundwater sources, ensuring cleaner and safer drinking water for communities.

International status:

The international status of research on biomonitoring pesticide pollution in soil using earthworms is quite advanced, with numerous studies conducted across the globe. Studies have shown that pesticides can significantly impact earthworms, affecting their growth, reproduction, behaviour, and enzyme activities even at low concentrations. Earthworms are widely recognized as reliable bioindicators for assessing soil health and contamination. Their sensitivity to environmental changes makes them ideal for detecting soil pollution. Researchers from various countries collaborate on studies related to earthworm biomonitoring, sharing knowledge and methodologies to advance the field.

National Status:

The national status of research on biomonitoring pesticide pollution in soil using earthworms in India is promising and growing. Several studies have been conducted to explore the potential of earthworms as bioindicators for soil pollution. The work by Keshamma (2022), Dhiman & Pant (2022) and other researchers shows the importance of biomonitoring of soil pollutants and its control through biological methods.

Significance of the study:

The study on biomonitoring of pesticide pollution in soil using earthworms holds significant importance for several reasons:

Environmental Impact:

1. **Indicator Species:** Earthworms are sensitive to changes in soil conditions and can serve as reliable bioindicators of soil health and contamination. This helps in early detection of pesticide pollution.
2. **Soil Health:** Monitoring pesticide levels using earthworms provides insights into the overall health of the soil ecosystem, which is crucial for maintaining biodiversity and ecological balance.

Agricultural Practices:

3. **Sustainable Agriculture:** Understanding how pesticides affect earthworms can lead to the development of more sustainable agricultural practices, reducing reliance on harmful chemicals.
4. **Crop Productivity:** Healthy soil supports better crop growth. By ensuring that pesticide use does not harm beneficial soil organisms like earthworms, we can maintain or even enhance crop yields.

Human and Animal Health:

5. **Food Safety:** Pesticide residues in soil can enter the food chain through crops. By monitoring and managing soil pesticide levels, we can ensure the safety of food produced.
6. **Public Health:** Reducing pesticide pollution in soil helps protect groundwater sources from contamination, ensuring safe drinking water for communities.

Scientific and Regulatory Advancements:

7. **Policy Development:** The findings from such studies can inform policymakers to the development of regulations that minimize environmental, and health risks associated with pesticide use.
8. **Research Advancements:** This study can advance scientific knowledge on the interactions between pesticides and soil organisms.

Economic Benefits:

9. **Cost-Effective Monitoring:** Using earthworms for biomonitoring can be a cost-effective and efficient method for assessing soil health.
10. **Ecosystem Services:** Healthy soils provide essential ecosystem services, such as nutrient cycling and water filtration, which have direct economic benefits for agriculture and environmental management.

6. Proposed work Plan / Formulation and Structure of Study: Year-wise Plan of work and targets to be achieved:

Year wise plan of work & targets	
Years	**Work plan**
Year 1	<u>Establishing Baselines and Initial Experiments</u> **Phase 1: Literature Review and Planning (Months 1-3)** ✓ Conduct an extensive literature review on pesticide pollution, soil health, and the role of earthworms as bioindicators. ✓ Define the research objectives, hypotheses, and detailed methodology. **Phase 2: Site Selection and Initial Soil Sampling (Months 4-6)** ✓ Select multiple study sites with varying levels of pesticide exposure (e.g., agricultural fields, non-treated areas). ✓ Conduct initial soil sampling to establish baseline data on soil health and existing pesticide levels. ✓ Analyze soil samples for physical, chemical, and biological properties. **Phase 3: Earthworm Selection and Laboratory Setup (Months 7-9)** ✓ Select suitable earthworm species (e.g., Eisenia fetida) for biomonitoring. ✓ Set up laboratory facilities for controlled experiments, including enclosures for earthworm populations and soil samples. **Phase 4: Preliminary Experiments (Months 10-12)** ✓ Conduct preliminary laboratory experiments to test the sensitivity of earthworms to different pesticide concentrations. ✓ Establish protocols for monitoring earthworm health, behavior, and mortality rates.
Year 2	<u>Field Experiments and Data Collection</u> **Phase 5: Field Deployment (Months 1-6)** ✓ Deploy earthworm populations in the selected field sites. ✓ Monitor earthworm health, population dynamics, and soil conditions regularly (e.g., monthly). ✓ Collect soil and earthworm samples for laboratory analysis. **Phase 6: Laboratory Analysis (Months 7-12)** ✓ Analyze collected samples for pesticide residues, soil health indicators, and earthworm biomarkers. ✓ Compare results from treated and control sites to assess the impact of pesticide pollution on earthworms and soil health.
Year 3	<u>Data Analysis & thesis writing</u> **Phase 7: Data Analysis (Months 1-6)** ✓ Perform statistical analysis on the collected data to identify significant trends and correlations. ✓ Interpret the results in the context of the initial hypotheses and existing literature. **Phase 8: Reporting and Dissemination (Months 7-9)** ✓ Prepare detailed research reports, including methodology, results, and conclusions. ✓ Publication on the research findings to peer-reviewed journals.

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